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EUPHAUSIIDS COLLECTED FROM THE AUSTRALIAN SECTOR OF THE SOUTHERN OCEAN DURING THE BIOMASS SIBEX CRUISE (KH-83-4)

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Abstract: Euphausiids were collected in the Australian Sector of the Southern ocean during the BIOMASS SIBEX cruise (KH-83-4), with a 10-foot Isaacs-Kidd Midwater Trawl. The biomass of euphausiids in the epi- and mesopelagic layers of the Southern Ocean was 0.58–16.96 g (wet wt.) per 1000 m³ and the total number of individuals was 6.8–103.1/1000 m³, accounting for 1.3–11.2% of the total biomass. Generally, the biomass and the total number of euphausiids in the Subtropical Water were the smallest in the Southern Ocean. Six genera including 18 species occurred, and *Thysanoëssa macrura*, *Euphausia superba*, *E. triacantha*, *E. crystallorophias* and *E. frigida* were collected from the Antarctic Zone. A total of 270 surface swarms were observed by sighting survey at 62°S and southward in the Antarctic Zone. The surface swarms of *E. superba* consisted almost exclusively of immature individuals, 22–25 mm in mean body length. The density of these swarms was 147–778 g/m³. As a result of a parallel grid survey by using the acoustic system, many scattering layers appeared at the depth between 10 and 100 m. The main organisms scattering were adults of *E. superba* and *T. macrura*. The evidence of mating of *E. superba* was recognized in the females larger than 38 mm in body length and the occurrence of many females with spermatophores attached suggests that they were in the main breeding season.

1. Introduction

The Crustacean Order Euphausiacea contain 85 species which are distributed throughout the oceans of the world (MAUCHLINE, 1980). In the Antarctic Ocean, there are 12 species of euphausiids that have a circumpolar distribution (MAUCHLINE and FISHER, 1969). The distribution of euphausiids in the Antarctic region is not definitely clarified yet.

Euphausia crystallorophias is a neritic species living under the ice along the edge of the continent. *Euphausia superba* is now being fished as an economic resource and this has stimulated much work directed at defining its distribution and occurrence. The large *E. superba* lives close to the ice edge and probably to a large extent under the ice but also extends northwards to the Polar Front, while *E. frigida* occurs between the ice edge and the Polar Front. The occurrence of *E. triacantha* is intimately associated with the Polar Front (BAKER, 1959). Three species, *E. vallentini*, *E. similis* and *E. longirostris* are subantarctic species although *E. similis* extends northwards to the Subtropical Convergence. According to BAKER (1965), *E. similis* var. *armata* lives north of

the Subtropical Convergence but penetrates subantarctic waters. JOHN (1936) classified *E. lucens* as a subantarctic species, but BAKER (1965) found it in greatest quantity north of the Subtropical Convergence. Obviously more information is required about this species. The separate distribution of *Thysanoëssa macrura* and *T. vicina* is not known well. RUSTAD (1934) found that *T. vicina* had a distributional range like that of *E. frigida*, while *T. macrura* penetrated further; more information on these species also is required.

Euphausiids aggregate but there are several types of their aggregation. They can be relatively disorganized, primarily due to the physical features of the environment such as the presence of a front. They can be patches, shoals or surface swarms (MAUCHLINE, 1980). The formation of surface or sub-surface swarms has been reported in *E. superba*, *E. vallentini*, *E. crystallorophias* and *E. similis* (MARR, 1962; NEMOTO *et al.*, 1969; RAGULIN, 1969; MAKAROV *et al.*, 1970; HAMNER *et al.*, 1983), and *E. lucens* and *E. frigida* from shoals (CUSHING and RICHARDSON, 1956; DE DECKER, 1973).

In this paper, the distribution of euphausiids in the Australian Sector of the Southern Ocean and the biological aspects of swarms of *E. superba* and *T. macrura* are described.

2. Methods and Materials

Euphausiids were collected in the Australian Sector of the Southern Ocean during

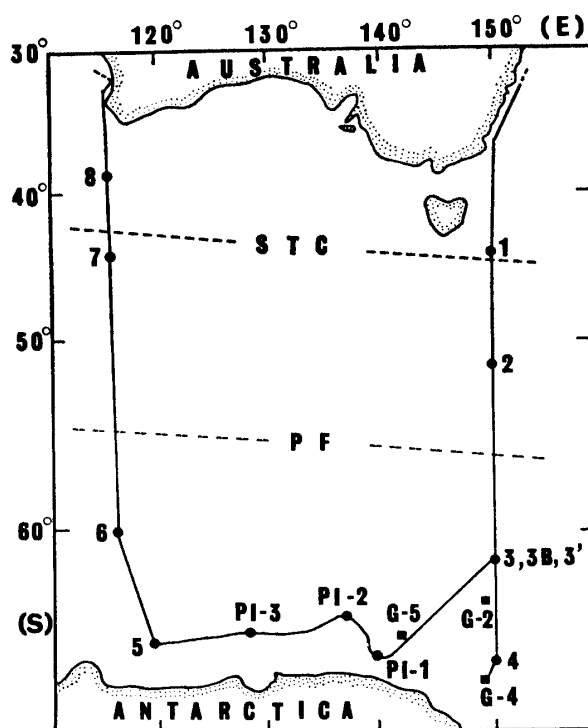


Fig. 1. Euphausiids sampling stations which were occupied during KH-83-4 cruise of the R. V. HAKUHO MARU in December and January 1983-84. STC and PF are the Subtropical Convergence and the Polar Front, respectively.

Table 1. Euphausiids (individ./1000 m³) collected from the Australian Sector of the South Ocean with 10-foot IKMT standard tows (3000 m wire out).

Sea area	Subtropical Zone				Subantarctic Zone				Antarctic Zone					
	1	8	2	7	3	3B	3'	4	PI-2	5	6			
Sampling station	'83/12/14	'84/1/28	'83/12/16	'84/1/27	'83/12/19	'83/12/26	'84/1/13	'83/12/21	'84/1/17	'84/1/19	'84/1/22			
Sampling date	45°07'S	39°58'S	52°07'S	44°48'S	61°27'S	61°26'S	61°32'S	64°56'S	64°14'S	65°02'S	60°00'S			
Sampling location	150 10 E	114 52 E	149 52 E	114 57 E	150 30 E	150 00 E	150 26 E	150 10 E	135 43 E	118 12 E	116 00 E			
Sampling layer (m)	0-1050	0-863	0-905	0-980	0-870	0-860	0-535	0-670	0-875	0-780	0-862			
Wet weight of euphausiids (g/1000 m ³)	1.03	0.79	10.79	2.87	1.22	1.86	7.58	1.50	0.58	16.96	2.21			
<i>Thysanopoda cornuta</i> ILLIG	0.8													
<i>T. acutifrons</i> HOLT and TATTERSALL	2.1		1.4	1.2										
<i>Thysanoëssa gregaria</i> G. O. SARS	0.8	0.2		0.3										
<i>T. macrura</i> G. O. SARS			4.7		0.4	2.1	5.9	0.1	14.2	15.9	6.1			
<i>Euphausia superba</i> DANA			66.5		0.4	0.3	9.1		2.6	15.5				
<i>E. vallentini</i> STEBBING														
<i>E. lucens</i> HANSEN				2.5										
<i>E. frigida</i> HANSEN														
<i>E. similis</i> G. O. SARS	1.3	3.5	0.1	8.2										
<i>E. similis</i> var. <i>armata</i> HANSEN	1.2	2.7		0.2										
<i>E. gibba</i> G. O. SARS		0.1												
<i>E. spinifera</i> G. O. SARS		0.2												
<i>E. longirostris</i> HANSEN	0.5			0.1										
<i>E. triacantha</i> HOLT and TATTERSALL			30.4		6.0	9.1	23.3	9.2	26.4	6.5	8.4			
<i>Nematoscelis megalops</i> G. O. SARS	11.0	1.6		16.8										
<i>Nematobrachion boöpis</i> (CALMAN)	0.6	1.2		2.2										
<i>Stylocheiron abbreviatum</i> G. O. SARS		0.4		0.1										
Total	17.5	10.7	103.1	31.6	6.8	11.5	38.3	9.3	43.2	37.9	16.1			

Note: *Euphausia crystallorophias* HOLT and TATTERSALL was captured from the surface layer of Stn. PI-1 (65°47'S, 140°22'E) with a 10-foot IKMT.

the BIOMASS SIBEX cruise (KH-83-4) of the R.V. HAKUHO MARU of the Ocean Research Institute, University of Tokyo.

The samples were collected with a 10-foot Isaacs-Kidd Midwater Trawl (IKMT) of 5 mm meshes at Stns. 1–8 and PI-2 (Fig. 1). The net was towed obliquely with a wire length of 3000 m behind the ship cruising at a speed of 2 knots. The depth of the net was estimated from the record of a Time-Depth Meter (Yanagi Instrument Co., Ltd.) installed on the net, and the estimated sampling layer with the 10-foot IKMT standard oblique tows is shown in Table 1. A flowmeter was mounted at the mouth of the net to estimate the volume of water filtered. At Stn. PI-1 (65°47'S, 140°22'E) located near Antarctica, nets were towed obliquely with a wire length of 200m to collect *E. superba*.

A parallel grid survey (course length 4 n mile; spacing interval 1 n mile) by using the acoustic system (Scientific echo sounder FQ 50 Furuno with 50 and 200 kHz) was carried out at Stn. G-2, G-4, G-5 and Stn. 5 (Fig. 1), and some IKMT haulings followed the echo survey to confirm which euphausiids constituted the major portion of scattering (INAGAKI *et al.*, unpublished data). Records of the parallel grid survey are as follows:

Station	Location	Date	Time
G-2	65°32'S 149°57'E	Dec. 22, 1983	0300–0700
G-4	63°36'S 150°51'E	Dec. 24, 1983	0230–0900
G-5	65°44'S 140°20'E	Jan. 15, 1984	0300–1130
5	64°55'S 117°55'E	Jan. 20, 1984	0300–1030

In the observation of the surface swarms of *E. superba* at Stn. PI-3, in January 1984, a 160 cm ORI net with 0.69 mm meshes (OMORI, 1965) was towed horizontally at the sea surface from the starboard as *E. superba* removed from the stern to the stern. A total of four tows was operated at Stn. PI-3 (PI-3-1 ~ PI-3-4). Euphausiid samples were preserved in 10% buffered formalin sea water immediately after the collection.

In the case of *E. superba* and *Thysanoëssa macrura*, the body length was measured from the tip of the rostrum to the apex of the telson and the wet weight was determined for both sexes. The process of maturation of the ovaries is well known in *E. superba* (MAKAROV and DENYS, 1980), and the females are classified according to the following stages: I) The thelycum bears no spermatophores, body is not swollen. II) Spermatophores present, their presence often causing the thelycum to appear brownish in color. Carapace is not swollen. III) Spermatophores present. Carapace swollen by enlarged ovary. IV) Spermatophores present. Carapace swollen in contour, but with a large hollow space owing to recent spawning of eggs.

In *E. superba* and *T. macrura*, the mating is performed by transfer of spermatophore from the male. Females with spermatophores attached were counted.

Sighting survey of the surface discoloration (ocher or brick red), which proved to be caused by the swarms of euphausiids (MARR, 1962), was made in the Antarctic Zone. Water temperature, salinity and dissolved oxygen were measured with CTDO system (Neil Brown MARK III-B) and XBT.

3. Results

3.1. Oceanographic condition

The oceanographic condition in the Australian Sector of the Southern Ocean during the BIOMASS SIBEX cruise (KH-83-4) was described by NAKAI *et al.* (1985).

Section I was situated along 150°E between 40° and 60°S, and Section II was along 115°E between 40° and 65°S.

Section I: The Polar Front is identified at 56.5°S as the northern limit of a minimum subsurface temperature of about 2°C. At 49°S, the Subarctic Front also seemed to have a remarkable horizontal temperature gradient. The Subtropical Convergence is well marked by a southern limit of surface saline water which coincides with a surface thermal frontal feature at 47°S. The area extending from the Polar Front to the Antarctic Surface Water is characterized by low temperature below 0°C and low salinity less than 34×10^{-3} . It is presumed that the Antarctic Divergence Zone exists around 65°S, though not clear. The area between the Subtropical Convergence and the Polar Front is called the Subantarctic Zone and is covered with the subantarctic surface water.

Section II: The Polar Front is found at 55°S as the northern limit of a 2°C isotherm in the subsurface minimum. The Subantarctic Front is found at 47°S as an account of deducing intense thermal discontinuity. The Subtropical Convergence seems not so clear judging from the temperature structure of the midlayer, but it is considered to be located at 43–44°S for this section which coincides with a weak surface front. It seems that the Antarctic Divergence Zone exists around 63°S, as shown by the temperature profile.

3.2. Distribution of euphausiids

The biomass of euphausiids in the epi- and mesopelagic layers of the Australian Sector of the Southern Ocean was 0.58–16.96 g/1000 m³, amounting to 1.3–11.2% of the total biomass of zooplankton and micronekton collected with a IKMT, and the total number of individuals was 6.8–103.1/1000 m³ (Table 1). Generally, the biomass and the total number of euphausiids in the Subtropical Water were the smallest in the Southern Ocean. Large variation of biomass was recognized between the Antarctic Ocean and the Southern Ocean.

Six genera with 18 species were collected from the Australian Sector of the Southern Ocean during the KH-83-4 Cruise (Table 1). *Nematobrachion boöpis* is a mesopelagic species, distributed in the Subtropical Zone and the Subantarctic Zone. *Thysanopoda cornuta*, *Euphausia gibba* and *E. spinifera* occurred in the Subtropical Zone and *E. vallentini* and *E. lucens* in the Subantarctic Zone. *Thysanopoda acutifrons*, *Thysanoëssa gregaria*, *E. similis*, *E. similis* var. *armata*, *E. longirostris*, *Nematoscelis megalops* and *Stylocheiron abbreviatum* are distributed in these two zones. From the Antarctic Zone, *Thysanoëssa macrura*, *E. superba*, *E. triacantha*, and *E. frigida* were collected. We could not find *E. crystallorophias* in the samples collected with IKMT standard oblique tows, but this species was captured from the surface layer of Stn. PI-1 (65°47'S, 140°22'E). *T. macrura* and *E. triacantha* were dominant species found at all stations, and they also occurred in the Subantarctic Zone. *E. superba* occurred at Stns. 3, 3B, 3', 4, PI-2 and 5, and adults were collected from Stns. 3B, PI-2, and 5 (Fig. 2).

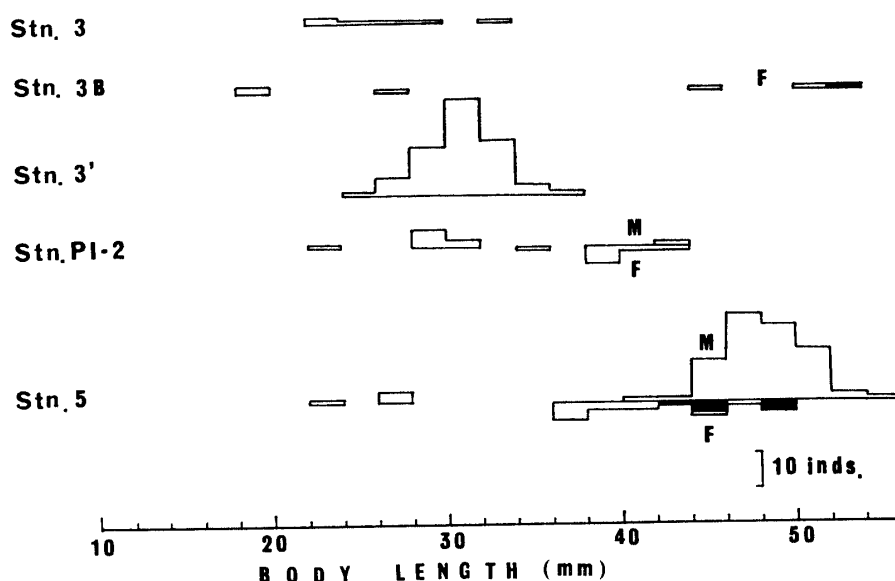


Fig. 2. Length-frequency histograms of *Euphausia superba* collected at Stns. 3, 3B, 3', PI-2 and 5 with 10-foot IKMT standard oblique tows (3000 m wire out) in the Antarctic Zone. F and M are females and males, respectively. Shaded area represents the proportion of individuals with attached spermatophores.

3.3. Aggregation of euphausiids

As a result of the parallel grid survey by using the acoustic system, many scattering layers appeared between the depths of 10 and 100 m. The characteristics of echo scattering varied with species, that is, *E. superba* was recognized at 200 kHz while *T. macrura* at 50 kHz. Main organisms of scattering were adults of *E. superba* at Stns. G-5 and 5 and *T. macrura* at Stn. G-4. The two species were captured at Stn. G-2 where *T. macrura* attained to 51.8% in individual number. In the case of *E. superba*, females accounted for more than 70% of the total number captured at each station, but their mean body length was smaller than that of males (Table 2). Usually, mature females of *E. superba* (Stage II–IV) have at least two spermatophores attached in their thelycum, sometimes more than two. Many spermatophores fall from the thelycum when the females reaches Stage III–IV. Many females with spermatophores were found in the samples, and especially at Stn. 5, 81.7% of the females collected, had spermatophores

Table 2. Biological analyses of sub-surface swarms of *Euphausia superba* collected from Stns. G-2, G-5 and 5.

Station	Male (M)		Female (F)		Stages of sexual maturity				F/M+F (%)
	No.	Mean body length (mm)	No.	Mean body length (mm)	I	II	III	IV	
G-2	16	44.0±2.4*	121 (29)**	43.8±4.2	0	4	95	22	88.3
G-5	16	43.7±3.6	50 (11)	41.3±4.6	28	9	10	3	75.6
5	38	45.2±3.3	180 (147)	43.3±3.6	0	41	124	15	82.6

* Standard deviation.

** Number of females with attached spermatophores.

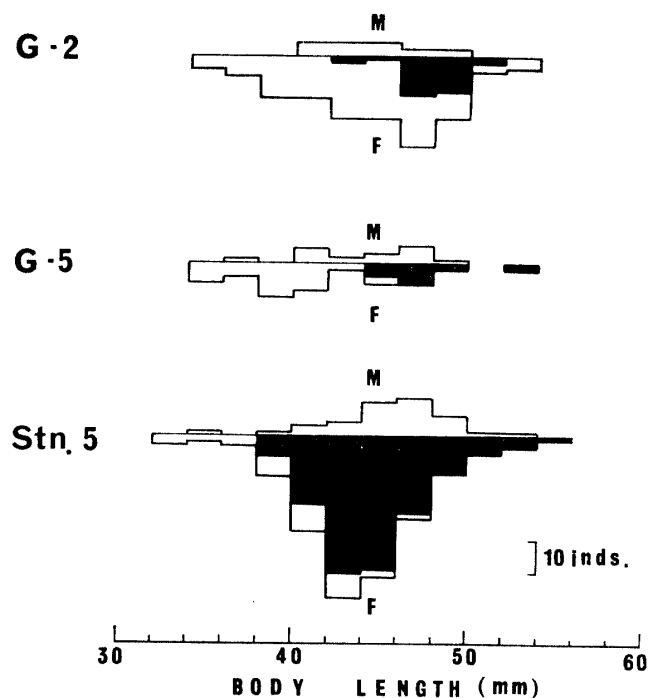


Fig. 5. Length-frequency histograms of males (M) and females (F) of *Euphausia superba* collected from sub-surface swarms at Stns. G-2, G-5 and 5 in the Antarctic Zone. Shaded area represents the proportion of individuals with attached spermatophores.

in their thelycum (Fig. 3). Immature females (Stage I) of *E. superba* were detected at Stn. G-5, and females after spawning (Stage IV) occurred at all stations (Table 2).

The proportion of *T. macrura* females captured at Stns. G-2 and G-4 was 76.2% and 58.0%, respectively. The mean body length of female was larger than that of male (Table 3). A few females had attached spermatophores (Fig. 4).

The surface swarms of *E. superba* at Stn. PI-3, consisted almost exclusively of immature individuals, 22–25 mm in mean body length and 75–106 mg in mean body weight (Table 4). There was not a large difference in their length-frequency histograms. The individuals collected from Stn. PI-3-4, were slightly larger in body length than those from other stations (Fig. 5). The towing distance of a 160 cm ORI net was approximately 100 m, which corresponds to the total length of the R. V. HAKUHO MARU. Fortunately, the net passed through the central part of surface swarms (10 m in length by 10 m in width) twice. The volume of water filtered through the swarms amounted to

Table 3. Biological analyses of the swarms of *Thysanoëssa macrura* collected at Stns. G-2 and G-4.

Station	Male (M)		Female (F)		F/M+F (%)
	No.	Mean body length (mm)	No.	Mean body length (mm)	
G-2	35	16.3±1.6*	112	19.3±2.7	76.2
G-4	84	17.2±1.0	116	17.9±1.3	58.0

* Standard deviation.

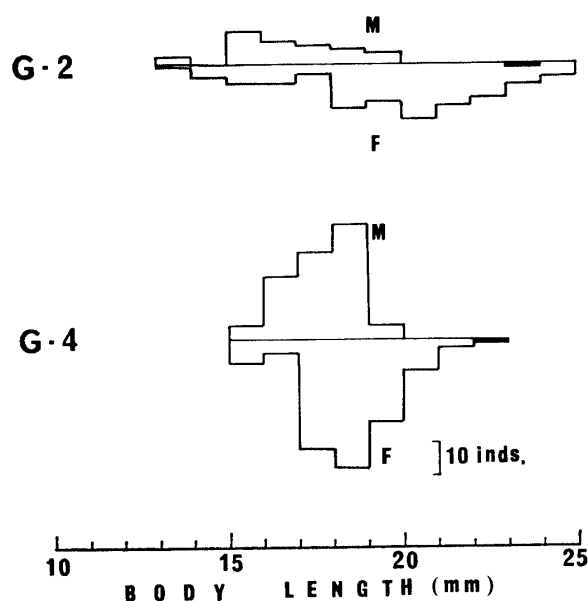


Fig. 4. Length-frequency histograms of males (M) and females (F) of *Thysanoëssa macrura* collected from sub-surface swarms at Stns. G-2 and G-4. Shaded area represents the proportion of individuals with attached spermatophores.

Table 4. Mean body length, weight and density of the surface swarms of *Euphausia superba* collected at Stn. P-3.

Station	Mean body length (mm)	Mean body weight (mg)	Density	
			individ./m ³	g wet wt/m ³
PI-3-1	24.6±2.6*	100.9±34.1		
PI-3-2	23.6±2.6	90.1±27.5	8630	778
PI-3-3	22.1±2.8	75.4±26.9		
PI-3-4	25.3±2.3	106.1±27.4	1390	147

* Standard deviation.

10% of the total volume. The density of these swarms was 8630 individ./m³ (778 g in wet weight) and 1390 individ./m³ (147 g), respectively (Table 4).

A total of 270 surface swarms were observed by sighting survey at 62°S and southward in the Antarctic Zone. Most of those swarms were small-scale ones, less than 20 m in length by 20 m in width, and large swarms of more than 100 m in length were occasionally recognized. Usually, surface swarms occurred in the night, especially after sunset or before sunrise (Fig. 6).

4. Discussion

Coelenterata, Tunicata and Pisces were major taxa in the Antarctic Zone and their biomass (wet weight) accounted for more than 80% of total zooplankton and micro-nekton collected by oblique hauls with a 10-foot IKMT (NEMOTO *et al.*, 1985). But the biomass of Euphausiacea ranged from 1.3 to 11.2%, 4.5% on the average. According

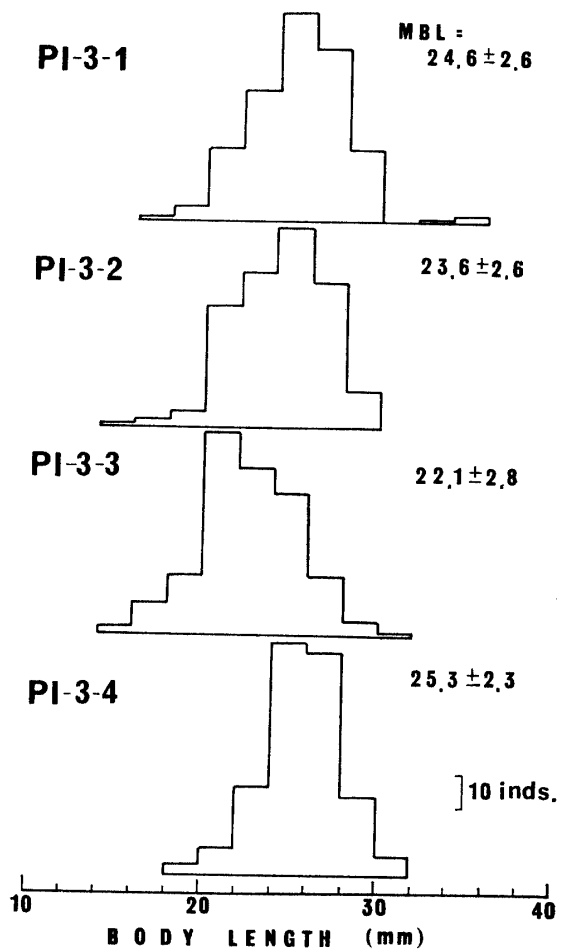


Fig. 5. Length-frequency histograms of *Euphausia superba* collected from surface swarms at Stn. PI-3. MBL is the mean body length with a standard deviation.

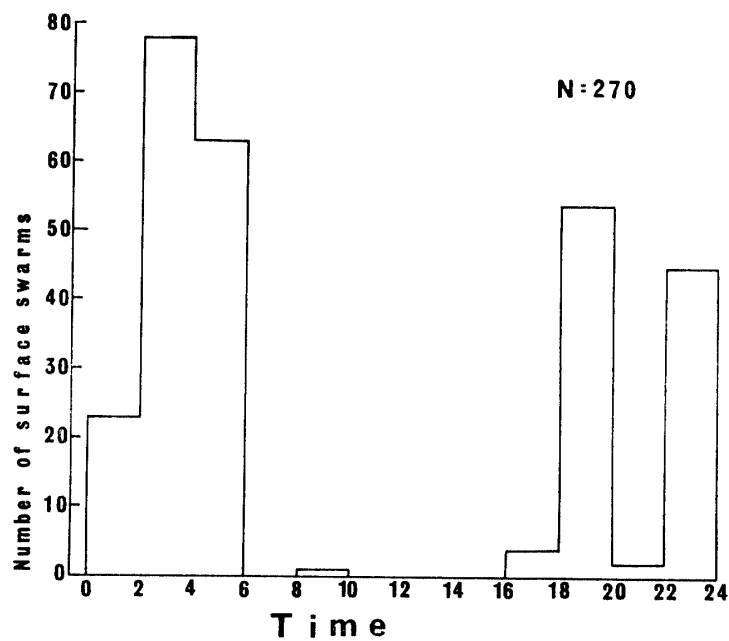


Fig. 6. Temporal change of the number of surface swarms of *Euphausia superba* observed by sighting survey at 62°S and southward in the Antarctic Zone.

to HOPKINS (1971), Copepoda were the dominant taxa in the Antarctic and Subantarctic Zones of the Pacific Sector, and their biomass (dry weight) amounted to about 67% of total zooplankton collected with a 50 cm (0.076 mm meshes), 50 × 50 cm (0.202 mm) and 100 cm (0.33 mm) plankton nets, and the biomass of Euphausiacea in the Subantarctic Zone, Polar Front and Antarctic Zone was recorded as 8.2, 11.0 and 7.5%, respectively. Despite of different sampling gears, the biomass of Euphausiacea was small and their normal density was very low (6.8–103.1 individ./1000 m³ or 0.58–16.96 g/1000 m³), when not in aggregation.

The distribution of euphausiids was limited strongly by the Subtropical Convergence and the Polar Front as the previous reports mentioned (RUSTAD, 1934; JOHN, 1936; BAKER, 1965). Occurrence of five epipelagic species, *Thysanoëssa macrura*, *Euphausia superba*, *E. triacantha*, *E. crystallorophias* and *E. frigida* in the Antarctic Zone was confirmed. But we could not find *Thysanoëssa vicina* because the mesh-size of IKMT (5 mm) was too large to collect this small euphausiid. The distance between the 115°E line and the 150°E line is about 2300 km, and the species occurring along both lines were different. *Thysanoëssa gregaria*, *Euphausia vallentini*, *E. lucens*, *E. similis*, *E. similis* var. *armata*, *E. spinifera*, *E. longirostris* and *Nematoscelis megalops* are distributed widely in the Australian Sector of the Southern Ocean except the Antarctic Zone (BRINTON, 1962, 1975; MAUCHLINE, 1980). But *E. vallentini*, *E. lucens* and *E. spinifera* were collected from only one station. *Thysanopoda acutifrons* is reported from the western part of the Australian Sector (BRINTON, 1962; MAUCHLINE and FISHER, 1969). We could find this species (15 individuals) at Stn. 7. It is impossible to discuss the distribution of euphausiids because of the deficiency of stations in the Subtropical Zone and the Subantarctic Zone. There is no sampling record of *Thysanopoda cornuta*, *E. gibba* and *Stylocheiron abbreviatum* in the Australian Sector of the Southern Ocean (MAUCHLINE, 1980). *T. cornuta* is a bathypelagic species which has not been caught frequently enough to define its distribution. In the Atlantic Ocean, this species is recorded in the east and west areas between 10° and 40°N and in the southeast area between 30° and 45°S. In the Pacific Ocean, this species is mainly reported from the tropical and subtropical regions (BRINTON, 1975). A total of 16 individuals were collected from Stn. 8. *E. gibba* is restricted in distribution to the Central South Pacific extending from 15° to 30°S in the east and from 13° to 38°S in the west. However, SAWAMOTO (1976) found two males and two females at one station located near the New Guinea. This species probably lives at depths between 280 and 500 m during the day, rising towards the surface at night (BRINTON, 1962). One individual of *E. gibba* occurred at Stn. 8. *Stylocheiron abbreviatum* is found in the Atlantic, Pacific, and Indian Oceans. In the Pacific Ocean, this species is recorded between 40°N and 40°S but it ascends from the colder parts of the California and Peru Currents. In the eastern equatorial region between 10° and 17°N, this species lives at depths between 75 and 300 m (BRINTON, 1975). *S. abbreviatum* occurred at Stn. 7 (1 individual) and Stn. 8 (8 individuals) along the 115°E line.

In our sighting survey, surface swarms of *E. superba* were frequently observed during the night. When ARIMOTO *et al.* (1979) investigated the diurnal variation of surface swarm in the ice edge area between 120° and 130°E in 1977–78 by sighting, the number of swarms increased remarkably after 8 pm and no swarm was recognized in the

daytime between the noon and 6 pm. Sub-surface swarms of *E. superba* which was recognized at 200 kHz was occurred at depths between 10 and 100 m by a parallel grid survey using the acoustic system. There are many reports describing the surface or sub-surface swarms of *E. superba*. There is substantial evidence that swarms are cohesive throughout 24 hours and perform, as a unit, a diurnal vertical migration, occurring the surface 20 m layer at night but moving downwards to the 60–100 m layer during the day (SASAKI *et al.*, 1968; SHUST, 1969). PAVLOV (1974) observed swarms rising to the surface at midnight and a second time at noon to feed; they swarmed actively when not feeding but dispersed to feed. Surface swarms of krill can be seen visually at distance as great as 1500–2000 m from a ship in dull weather but are usually absent during sunny weather (SHUST, 1969). Thus the behavior of swarms is irregular.

MAUCHLINE and FISHER (1969) discussed the age composition of swarms of *E. superba*, and stated any one swarm is often composed of individuals in a relatively restricted size range. These reports agree with the results of our investigation, that is, mature individuals with 40–50 mm body length made up a large part of sub-surface swarms at Stns. G-2, G-5 and 5. On the other hand, surface swarms at Stn. PI-3 were composed of immature *E. superba* with 20–30 mm body length. The breeding season of *E. superba* is the summer between November and April (MACKINTOSH, 1972). The evidence of mating was recognized in the female above 38 mm in body length, and the occurrence of many females with attached spermatophores at Stn. 5 in January 1985, suggests that they were in the main breeding season. The copulation takes place at depths between 10 and 100 m during the whole day. Low sex ratio of males in the swarms might be related to the breeding.

There are many reports which mentioned the density of swarms of *E. superba* (*cf.* MAUCHLINE, 1980). Some examples of the density in terms of the number or weight of individuals per m³ are as follows: more than 60000 (MARR, 1962), 50000–60000 (RAGULIN, 1969), 20000–30000 (HAMNER *et al.*, 1983), 1.2–438.4 g (MATUDA *et al.*, 1979) and 200 g–2 kg (NEMOTO and MURANO, 1979). The surface swarms collected at Stn. PI-3, are not dense.

The swarms of *T. macrura* were recognized at Stns. G-2 and G-4. At Stn. G-2, *T. macrura* was collected together with *E. superba*. Judging from the different characteristics of echo scattering, it may be concluded that each species independently forms sub-surface swarms in the narrow area. The spawning season of *T. macrura* commences as early as September in the Scotia Sea, and the spawning begins much earlier in West-Wind-Drift waters than in waters of the Weddell Sea (MAKAROV, 1979). A small number of females had spermatophores in their thelycum (Fig. 4), so it is possible that December is not the main breeding season of *T. macrura* in the Antarctic Zone in the Australian Sector of the Southern Ocean.

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